Property-based Testing for non-functional requirements

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Outline

1. Introduction
2. Functional testing
3. Non-functional testing
4. Feedback
Introduction
Why should we test software?

- It increases your **confidence** in the code you write.
- Tests could be used as **documentation**.
- It helps **finding bugs earlier**, so the impact is much lower.
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- It increases your **confidence** in the code you write.
- Tests could be used as **documentation**.
- It helps **finding bugs earlier**, so the impact is much lower.
- Reduce **costs**:
  - “50% project budget”
  - “At least 1/3 and probably more than 1/2 of the project budget”
Introduction

Remembering some concepts...

- **Successful** tests are those that **find bugs**.

- Testing **cannot prove** that the software **has not bugs**.

- Testing **cannot prove** that the software **fulfill its specification**.

- Sometimes, **more testing** implies finding **less bugs**.
Introduction
Good practices

- Tests should be **independent** from each other.
- Tests should be **repeatable**.
- Tests should be **guided by the specification**.
- After testing, the system should **remain as it was**.
- Test code should be **separated from the code** itself.
Introduction
Testing techniques

- **Static vs dynamic**
  - Software must be running or not

- **White-box vs black-box**
  - We need access to software internals or not

- **Positive vs negative**
  - Software testing in normal conditions or not
Introduction

Testing levels

**Unit testing**: isolate each part of the program and show that the individual parts fit the specification.

**Integration testing**: individual software modules are combined and tested as a group.

**System testing**: the whole software system is evaluated

**Acceptance testing**: the software we built fits business requirements.
Depending on what we want to test:

- **Functional testing:** what the software will do.
- **Non-functional testing:** related to requirements that describe not what the software will do, but how the software will do it.

But in general, testing is identified by its functional side...
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Functional testing

In the Erlang world
Functional testing
In the Erlang world

- **EUnit**

Typical assertions
- `assert(BoolExpr)`
- `assertNot(BoolExpr)`
- `assertMatch(Pattern, Expr)`
- `assertEqual(Expected, Expr)`

Example!
Functional testing
In the Erlang world

- **EUnit**
  - The classic xUnit approach
  - Test cases are implemented manually as part of test functions
  - Integrated with *rebar*.
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Functional testing
In the Erlang world

- **CommonTest**

  ▶ Automates the execution of test functions.
  ▶ We can analyse past execution of test functions.
  ▶ Includes coverage data.
  ▶ Setting it up can be difficult.
  ▶ Ideal for integration testing.
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In the Erlang world

- **CommonTest**
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  - We can avoid certain testcases
  - Test suites can affect to different Erlang nodes.
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Example!
Functional testing
Property-based testing

Uses declarative statements to specify properties that the software needs to satisfy according to its specification.
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Using this approach:

- Test cases can be automatically derived from those properties.
- Test cases can be automatically run and diagnosed.
Functional testing

Property-based testing

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The tools we use to perform PBT in Erlang:

- **QuickCheck / PropEr**
Property-based testing

The process

- Define properties for our code.
- Run test cases using QuickCheck/PropEr generators.
- Check whether the defined properties hold or not.
Property-based testing

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  - When a failing test case is found, QuickCheck/PropEr automatically shrinks it to the smallest equivalent counterexample.
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- Properties themselves are also **written in Erlang**.
- **State-machine** based testing for complex systems.
“After we have applied the delete function to a list of numbers and an specific number, such number should not appear in the resulting list.”
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Property in QuickCheck:

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\text{prop_lists_delete()} -> \\
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\quad \text {?FORALL}(\text{List}, \text{eqc_gen:} \text{list(eqc_gen:} \text{int}()), \\
\quad \text{not lists:member}(I, \text{lists:delete}(I, \text{List}))).
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```
Property-based testing

Simple example

Sample of generator output:

```
2> eqc_gen:sample(eqc_gen:list(eqc_gen:int())).
[10,-2,-9,6]
[-8,6,-11]
[-7,-3,7]
[3]
[]
[11,8,14,12,3]
[-4]
...
```
Running test cases means running the property.
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Running the property:

3> eqc:quickcheck(test:prop_lists_delete()).

............................................................

OK, passed 100 tests

true
Property-based testing

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Running the property:

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QuickCheck tutorial by Thomas Arts
Functional testing is not enough...

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- Or even when the system is deployed!
Non-functional testing

Many requirements can be considered as non-functional (also known as extra-functional):
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- Performance
- Dependability
- Security
- Reliability
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These requirements are generally informally stated, they are often contradictory. It is difficult to keep traces of what we have tested.
Non-functional testing

The question

Can we property-based test any of these non-functional requirements?
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Work in progress
Library for testing non-functional requirements to be used in combination with property-based testing tools
Non-functional testing

Among all possible non-functional requirements, select one and implement a prototype of properties.

- Performance from a black-box approach
- Possible properties:
  - "The response time is less than a value T"
  - "The average response time of N requests is less than a value T"

Example! EUC (2014)
Non-functional testing

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Performance

From a black-box approach

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**Performance**

- From a **black-box** approach
Non-functional testing

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Example!
Performance testing

Before running the tests, set a specific **workload** in the system. Possible integration with:

- Tsung
- Megaload
Performance testing

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Use `?SETUP` macro.

PBT is partially integrated in Megaload. Diana Corbacho’s tutorial.
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Performance testing

Queue example

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- We can build a **state-machine in combination with our library** to check that.
Performance testing

Queue example

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Example!
Feedback

More properties related to performance?

Simulate increasing memory, disk or network usage

Move to grey-box testing to get info at earlier stages?

What non-functional requirement would you like to have tools for testing it?

How could PBT help when testing that requirement?
More properties related to performance?
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Feedback

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Feedback

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- Move to grey-box testing to get info at earlier stages?
- What non-functional requirement would you like to have tools for testing it?
- How could PBT help when testing that requirements?
Audience! thanks